Event by Event fluctuations and Inclusive Distributions*

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It is now widely recognized that studies of event-by-event fluctuations observed in high energy multi-particle reactions may become an important tool in attempts to understand the underlying dynamics of ultra-relativistic heavy ion collisions. [1-3]. It has for instance be proposed that the measurement of even-by-even fluctuations of the temperature via e.g. the transverse momentum spectrum could provide information about the heat capacity of the system generated in these collisions [2,3]. Also, by investigating event-by-event fluctuations one may be able to distinguish distinct event classes. The analysis of heavy ion collisions on an event-by-event basis has been pioneered by the NA49 experiment. First, preliminary results [1] seem to indicate that the observed fluctuation in the mean transverse momentum as well as the kaon to pion ratio are of Gaussian shape.

It seems therefore interesting to study in some detail what is the information content of such measurements and to what extent they actually differ from the more conventional treatment of particle spectra. In the present work we discuss the relation of event-by-event fluctuations to the standard inclusive (multi-particle) distributions.

Our conclusions can be summarized as follows: Gaussian event-by-event fluctuations of any (multi-particle) observable can be expressed in terms of inclusive distributions, provided the inclusive distributions are known up to twice the order of the observable under consideration.

Or in other words in order to express event-by-event fluctuations of a single particle observables one needs to know the two-particle inclusive distribution etc. Fluctuations of ratios of observables, on the other hand, cannot simply be expressed in terms of ratios of inclusive measurements. However, as long as the central limit theorem can be applied, i.e. the observables involved are dominated by independent single particle emission, and the observed multiplicities are reasonably high, the knowledge of inclusive distribution of twice the order of the observables under consideration again is sufficient.

As a consequence of these results, as long as the fluctuations are Gaussian, they can be addressed by a two-arm spectrometer. Thus, provided, STAR [4] finds a Gaussian shape of event-by-event fluctuations at RHIC, their magnitude can be also measured by other detectors such as Phenix and Phobos. Of course in oder to establish whether or not the fluctuations are Gaussian a large acceptance detector such as STAR is required.

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